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Two new-born great white sharks, *Carcharodon carcharias* (Linnaeus, 1758) (Lamniformes; Lamnidae) from Turkish waters of the north Aegean Sea

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On July 1, 2008, a new-born great white shark was captured by a commercial gill-netter off the coast of Altınoluk (Edremit Bay, north Aegean Sea), followed by the capture of another juvenile three days later at the same locality during a haul of bottom long-line set by the same fisherman. Before the present study, the smallest free-living white shark from the Mediterranean Sea appeared to be a 142 cm TL small female juvenile, captured off Mazara del Vallo in August 11, 1983 (catalog No. MSI-0285J, appendix 1 in FERGUSSON, 1996). Therefore, specimen No. 1 (125,5 cm TL) of the present study is possibly the smallest neonate white shark from Mediterranean waters to date.

Key words: *Carcharodon carcharias*, great white shark, reproduction, breeding ground, neonate, morphometrics, north Aegean Sea

INTRODUCTION

The great white shark, *Carcharodon carcharias* (Linneaus, 1758), is a cosmopolitan species in warm to temperate waters of the world's oceans (COMPAGNO, 1984). Although the white shark often occurs close inshore (COMPAGNO, 1984; LIPEJ *et al*., 2004), recent research revealed that it migrates along transoceanic routes (BONFIL *et al*., 2005). The historical and contemporary records of this apex predator in the Mediterranean Sea are well documented (BARRUL, 1993-94; BARRULL & MATE, 2001; BEN-TUVIA, 1971; CELONA *et al*., 2001; CELONA, 2002; DE MADDALENA, 2000, 2002, 2006; DE MADDALENA *et al*., 2001; FERGUSSON, 1996; KABASAKAL, 2003, 2008; KABASAKAL & KABASAKAL, 2004; MOREY *et al*., 2003; SAÏDI *et al*., 2005; SOLDO & JARDAS, 2002).

Contrary to Mediterranean records, the presence of *C. carcharias* in Turkish waters has always been a point of controversy. DEVEDJIAN (1926) reported on a great white shark (referred to as *Carcharodon rondeletii* by the author) landed at İstanbul Fish Market in the early 20th century. Nineteen years later another great white shark was entangled in a fish trap set in coastal Marmaric waters (DEVECİOĞLU, 1945). Besides this scientific evidence indicating the Marmaric presence of the great white shark, at least 10 specimens of *C. carcharias* have been recorded from the Bosphoric waters of İstanbul city (KABASAKAL, 2003). On the other hand, between 1991 and 1996, 4 great white sharks were captured or sighted along the Anatolian coast of the north Aegean Sea (KABASAKAL & KABASAKAL,

2004; KABASAKAL, 2008). *C. carcharias* is also recounted in general ichthyological studies of Turkish seas (e.g., AKŞIRAY, 1987; BİLECENOĞLU *et al*., 2002; DEVEDJİAN, 1926; MATER & MERİÇ, 1996).

In this paper details of two captured new-born great white sharks in Turkish waters are presented.

MATERIAL AND METHODS

The present study is part of an extensive area of research (KANIT Project – Türk Sularında Yaşayan Köpekbalıklarının Tesbiti Projesi (Identifying the Sharks of Turkish Waters); KANIT means "proof" in Turkish) which was initiated in 2000 by the Ichthyological Research Society (IRS) to determine the current status of sharks of Turkish waters. Because of myths and uncertainties regarding large sharks which should be clarified, they are considered as the main focus of the KANIT Project. The first results of the *C. carcharias* substudy in Turkish waters were already reported by KABASAKAL (2003); KABASAKAL & KABASAKAL (2004) and KABASAKAL (2008).

On July 1, 2008, a new-born great white shark of 125,5 cm TL (specimen No. 1, Fig. 1) was captured by a commercial gill-netter off the coast of Altınoluk in the north Aegean Sea (Fig. 2), followed by the capture of another new-born great white shark of 145 cm TL (specimen No. 2; Fig. 1) three days later in the same locality during a haul of bottom long-line. Fishermen tried to keep both great white sharks alive and display them in a 25 ton marine aquarium. However, both sharks survived only 12 hours and 27 hours, respectively. After the death of both specimens, they were preserved in ice and transported to İstanbul Fish Market for delivery to IRS.

Morphometric measurements of the specimens were recorded to the nearest 0,5 cm, following the procedure outlined by COMPAGNO (1984). Total length (TL) is the distance between the tip of the snout and the tip of the dorsal lobe of the caudal fin, where the caudal fin is placed in it's natural position. All of the measurements

Fig. 1. Carcharodon carcharias *(Linnaeus, 1758), specimen No. 2 in İstanbul Fish Market, (Photo: Hakan Kabasakal)*

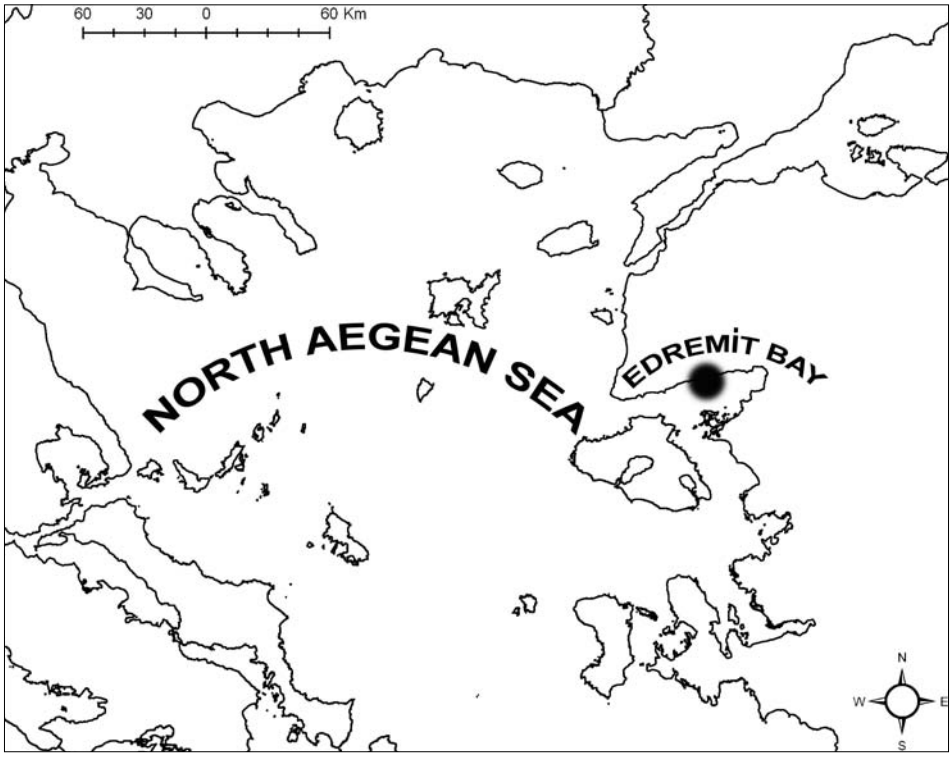
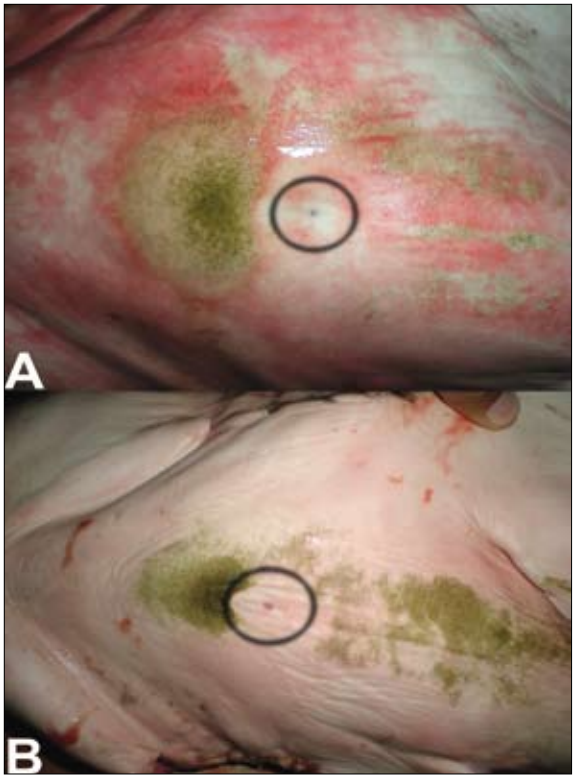


Fig. 2. Fishing locality of specimen Nos. 1, 2 in Edremit Bay (black circle)

Fig. 3. Umblical scars of neonate specimens. (A) specimen No. 2; (B) specimen No. 1, (Photo: H. Kabasakal)



were recorded on the fresh specimens. Examination of the sharks was filmed and photographed. Upper and lower jaws were removed, cleaned and dried. Caudal fins were removed and preserved in 5 percent formalin. Jaws, caudal fins and visual evidence are kept in the archieves of IRS and are available for inspection on request.

RESULTS

Morphometric data of the examined specimens are presented in Table 1. Both specimens had clear umblical scars on their throats (Fig. 3), which indicated new-born great white sharks. Triangular teeth with serrated edges were visible on the upper jaw while teeth on the lower jaw were spike-like with very slight serrations (Fig. 4). The teeth were fully erected on the upper and lower jaws. The tip of the snout of specimen No. 1 was damaged due to entanglement in the net.

The dorsal part of the body is dark grey and the ventral part is whitish on live specimens.

Table 1. Morphometric measurements of specimen Nos. 1, 2

Measurements (cm)	sp. No. 1	sp. No. 2	Mean	% of TL of mean
Total length	125,5	145	135,25	100
Precaudal length	98	114,5	106,25	78
Pre-second dorsal length	83,3	96,3	89,8	66,4
Pre-first dorsal length	47,4	53,4	50,4	37,26
Prepectoral length	34,9	39,7	37,3	27,57
Prepelvic length	67,4	78,8	73,1	54,04
Snout-vent length	69,3	82,2	75,75	56
Preanal length	86,8	100,1	93,45	69,09
Interdorsal space	25,8	29,3	27,55	20,36
Dorsal-caudal space	13,7	17,4	15,55	11,49
Pectoral-pelvic space	29,0	31,6	30,3	22,4
Pelvic-anal space	13,7	14,1	13,9	10,27
Anal-caudal space	10,9	13,4	12,15	8,98
Head length	35,3	40,2	37,75	27,91
Prebranchial length	26,4	33,5	29,95	22,14
Preorbital length	8	9,4	8,7	6,43
Prenarial length	5	6,5	5,75	4,25
Preoral length	8,2	10,1	9,15	6,76
Eye length	1,6	1,8	1,7	1,25
Eye height	1,9	2,4	2,15	1,58
Interorbital space	9,6	9,8	9,7	7,17
Nostril width	2,1	2,1	2,1	1,55
Internarial space	5,0	5,8	5,4	3,99
Mouth width	10,4	12,5	11,45	8,46
Mouth length	8,6	8,6	8,6	6,35
Intergill length	7,4	9,6	8,5	6,28
First gill slit height	11,4	14,0	12,7	9,39
Second gill slit height	10,7	13,1	11,9	8,79
Third gill slit height	10,9	13,5	12,2	9,02
Fourth gill slit height	10,5	12,7	11,6	8,57
Fifth gill slit height	11	13,6	12,3	9,1
Pectoral anterior margin	26,2	29,4	27,8	20,55
Pectoral base	10,2	9,2	9,7	7,17
Pectoral inner margin	7,0	7,9	7,45	5,5
Pectoral posterior margin	21,3	24,8	23,05	17,04
Pelvic anterior margin	7,2	7,1	7,15	5,28
Pelvic length	10,4	11,8	11,1	8,2
Pelvic base	7,5	6,8	7,15	5,28
Pelvic inner margin length	3,7	3,8	3,75	2,77
Anal anterior margin	3,3	4,4	3,85	2,84
Anal length	3,2	4,5	3,85	2,84
Anal base	1,6	2,1	1,85	1,36
Anal inner margin	2,3	2,6	2,45	1,8
First dorsal height	10,3	11,8	11,05	8,17
First dorsal anterior margin	14,1	17,7	15,9	11,75
First dorsal base	11,1	13,5	12,3	9,09
First dorsal inner margin	3,0	2,9	2,95	2,18
First dorsal posterior margin	9,5	11,9	10,7	7,91
Second dorsal length	2,3	2,2	2,25	1,66
Second dorsal anterior margin	3,2	3,5	3,35	2,47
Second dorsal base	1,6	2,1	1,85	1,36
Second dorsal inner margin	1,8	2,3	2,05	1,51
Second dorsal posterior margin	1,6	2,0	1,8	1,33
Dorsal caudal margin	29,2	31,1	30,15	22,29
Preventral caudal margin	21,1	23,2	22,15	16,37
Subterminal caudal margin	1,9	2,2	2,05	1,51
Terminal caudal lobe	6,6	7,1	6,85	5,06
Clasper inner length	7,8	9,4	8,6	6,35
Pectoral anterior margin	26,2	29,4	27,8	20,55
Pectoral base	10,2	9,2	9,7	7,17

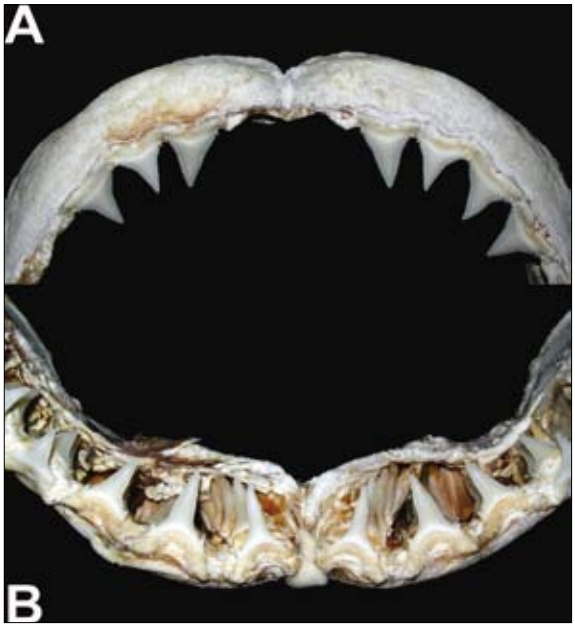


Fig. 4. Upper (A) and lower (B) jaw teeth of specimen No.2 (125,5 cm TL), (Photo: Hakan Kabasakal)

Distinctive reddish markings were visible on the ventral surface of death specimens (Fig. 5). A black blotch is visible on the ventral surface of pectoral fins, as well as edges of pectoral fins surrounded with a thin black strip on the ventral surface (Fig. 5).

Claspers of both males were uncalcified and soft. The tips of the claspers were almost at the same level with the tips of the pelvic fins (Fig. 6).

The stomach content of specimen No. 1 (125,5 cm TL) included many embryonic teeth and mucus like substances (Fig. 7). A few teeth and remains of a bony fish (probably the bait) were found in the stomach content of specimen No. 2 (145 cm TL). A greenish-brown material that contained unidentified crystal-like pieces were found in the spiral intestine of both specimens.

The examined great white sharks were accidentally captured by means of artisanal fishing gear, gill-net and bottom long-line which were set in inshore waters approx. 1 km off the Altınoluk coast.

DISCUSSION AND CONCLUSIONS

The length at birth of *C. carcharias* can be estimated from the sizes of the largest embryos and the smallest free-living young (FRANCIS, 1997). According to KOHLER *et al.* (1995), the size of the smallest reliably-measured free-living white sharks from western North Atlantic

Fig. 5. Coloration of specimen No. 2 (145 cm TL) from the ventral side, (Photo: Hakan Kabasakal)

Fig. 6. Claspers of specimen No. 2, (Photo: H. Kabasakal)

waters appear to be 122 cm. Before the present study, the smallest free-living white shark from the Mediterranean Sea was a 142 cm TL small female juvenile, captured off Mazara del Vallo on August 11, 1983 (catalog No. MSI-0285J, appendix 1 in FERGUSSON, 1996). Therefore, specimen No. 1 (125,5 cm TL) of the present study is possibly the smallest neonate white shark from Mediterranean waters to date. The size of specimen No. 1 of the present study is less than the smallest embryo (132 cm TL) recently reported by SAÏDI *et al.* (2005).

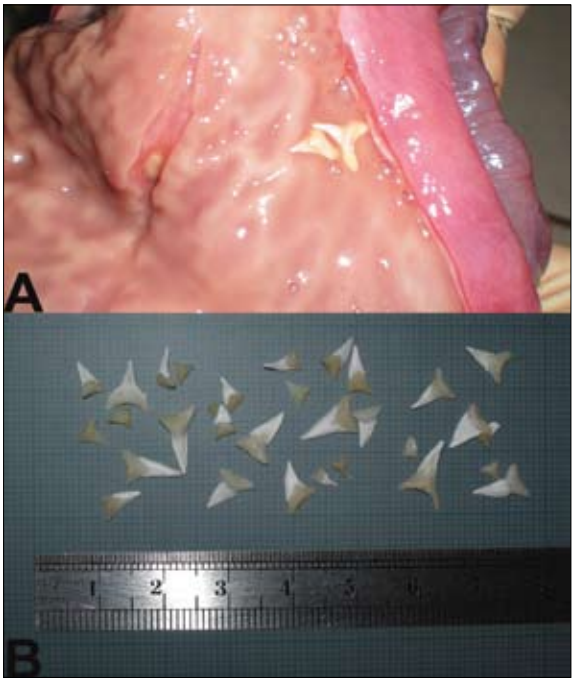


Fig. 7. (A) Embryonic teeth and mucus-like substance in the stomach of specimen No. 2; (B) embryonic teeth of specimen No. 1, (Photo: Hakan Kabasakal)

Most lamniforms possess a unique heterodont dentition called the 'lamnoid tooth pattern', which is characterized by teeth usually well differentiated along jaws (SHIMADA, 2002). In smaller individuals of *C. carcharias* (<214 cm TL free-swimming individuals and >143 cm TL embryos) one or two pairs of lateral cusplets tend to occur with a lanceolate central cusp that may partly or entirely lack serrations on its edges (SHIMADA, 2002). Functional teeth on the lower jaw of specimen No.1 possess one lateral cusplet on both sides of a lanceolate central cusp; upper jaw teeth possess one lateral cusplet on both sides of a well-serrated triangular central cusp as well (Fig. 4). UCHIDA *et al.* (1996) found numerous teeth in the stomach contents of two embryonic great white sharks, 135 cm TL (No. 1) and 140 cm TL (No. 8), found in a 515 cm TL female caught on May 22, 1992, in a net off Toyo, Japan. According to UCHIDA *et al.* (1996), teeth on the upper and lower jaws of the No. 8 embryo were erect and seemed fully functional. Teeth on the upper and lower jaws of specimen No. 2 (145 cm TL) were also erect and seemed fully functional and, apart from a lacerated bony fish, no embryonic teeth were found in the stomach contents. On the other hand, teeth of specimen No. 1 (Fig. 4) were also erect, but appeared not to be fully functional, due to poor connection of teeth in the gum. Some of the upper jaw teeth were easily displaced without forcing them during the dissection of the jaws. Numerous embryonic teeth and mucus-like substances were found in the stomach of specimen No. 1 (Fig. 7). UCHIDA *et al.* (1996) also found embryonic teeth together with mucus-like substances in the stomachs of two embryos (No. 1 and No. 8). SAÏDI *et al.* (2005) reported that the stomachs of three of the four embryos found in a pregnant female great white shark from the Gulf of Gabés, were full of yolk.

A clear yolk sac scar is seen in the center of the throat of the No. 6 embryo from the Toyo

specimen, a 150 cm TL male (Fig. 4B in UCHIDA *et al.* 1996). Both specimens No. 1 and No. 2 possess yolk sac scars on the throat as well (Fig. 3). While the scar of specimen No. 2 is almost healed (Fig. 3A), an unhealed scar is seen on specimen No. 1, in which the muscle tissue is still visible, similar to the yolk sac scar of the No. 6 embryo of UCHIDA *et al.* (1996). Such evidence, the loose attachment of jaw teeth, lateral cusplets, the presence of embryonic teeth and mucus-like substances in the stomach and an unhealed yolk sac scar suggest that specimen No. 1 was possibly born only a couple of days or weeks before its capture on July 1, 2008.

Pregnant females with developing or near-term embryos were already caught in the western and central Mediterranean, with the captures mainly being reported off the Tunisian coast (FERGUSSON, 1996; SAÏDI *et al*., 2005). On 26 February 2004, a pregnant female great white shark (587 cm TL) was captured by a purse-seining boat in the Gulf of Gabés (SAÏDI *et al*., 2005). The mother was eviscerated and four developing embryos, ranging from 132 to 135 cm TL (mean: 133.6±1.2) and full mass between 27.65 and 31.50 kg (mean: 29.602±1.693), were found (SAÏDI *et al*., 2005). Previous recordings of pregnant females and small free-swimming white sharks have come from the same areas, especially in Tunisian waters (FERGUSSON, 1996), as well as the recent specimens described by SAÏDI *et al.* (2005). This is in agreement with Fergusson's opinion (2002; cited in SAÏDI *et al*., 2005) that considers the central Mediterranean Sea as a nursery site for white sharks.

A pregnant female great white shark measuring 425 cm TL that was captured off Alexandria, Egypt, contained 9 embryos measuring 60 cm in length (TORTONESE, 1956). This eastern Mediterranean record of a pregnant great white shark has been considered questionable, mainly due to stated masses of the embryos which is surely erroneous while the exact identity of the species is not reliable (FERGUSSON, 1996). Hence, two juvenile great white sharks measuring 180 cm and 230 cm TL were caught off Thásos and Kavállah in the north Aegean Sea, respectively (FERGUSSON, 1996). A 200 cm TL juvenile great white shark was caught by rod and reel off Acre, Israel (BEN-TUVIA, 1971). In spite of the record of a pregnant female, though questionable, or the captures of several juveniles in the Aegean and eastern Mediterranean Seas, the possibility of a breeding ground for *C. carcharias* in the eastern Mediterranean basin has always been debateable. The recent captures of two new-born great white sharks off the Altınoluk coast are solid evidence suggesting that a breeding ground for *C. carcharias* may exist in Edremit Bay in the northeastern Aegean Sea (Fig. 2). Moreover, interviews with the fisherman who caught specimens 1 and 2 of the present study revealed the capture of another juvenile great white shark in the same locality in the summer of 2007, supporting the presumption of a breeding ground in Edremit Bay.

Pregnant females carrying embryos longer than 127 cm TL have been caught from midwinter to summer indicating that parturition occurs in spring or summer worldwide (FRANCIS, 1997). On the basis of the spatiotemporal distribution of juvenile great white sharks <185 cm TL, and a recent record of a pregnant female of >500 cm TL from Tunisian waters, FERGUSSON (1996) suggests that parturition likely occurs in late summer and early fall, with nursery grounds existing in Sicilian and Tunisian neritic waters. Despite the large length and mass of four embryos found in the pregnant female great white shark reported by SAÏDI *et al.* (2005), the high percentage of yolk mass (43-45%) of the Tunisian embryos suggested that they were not near-term. Specimens 1 and 2 were caught on July 1 and 4, 2008, respectively, so the dates of the captures of these new-born great white sharks coincide well with the mentioned parturition period of *C. carcharias* worldwide.

The pressure of artisanal fisheries on lamniform sharks in coastal Mediterranean waters is obvious. Lamniform sharks, juvenile specimens in particular, are taken by gill- or trammel-netters as bycatch or targeted species in varying amounts. The deployment of fishing gears in coastal waters, particularly in possible breeding grounds, creates a serious threat to the survival of these vulnerable species. LIPEJ *et al.* (2000)

and KABASAKAL (2004) reported the accidental captures of juvenile basking sharks *Cetorhinus maximus* in nearshore waters off Piran (Slovenia) and Turkish coastal waters of the Mediterranean, respectively, pointing to the bycatch risk to basking sharks created by the deployment of stationary nets in neritic waters. In addition to basking sharks, young thresher sharks, *Alopias vulpinus*, were caught by trammel-netters in Tunisian and Turkish coastal waters (HATTOUR & NAKAMURA, 2004; KABASAKAL, 2007). A few bigeye thresher sharks (*A. superciliosus*) were also caught by coastal netters in Turkish waters in previous years (KABASAKAL & KARHAN, 2007; CLO *et al*., 2008). Most of the mentioned specimens were caught during the period from midspring to late summer. Besides the juveniles, which stay in coastal nursery areas during early development, adults seasonally approach neritic waters due to several biological requirements such as parturition or feeding. Thus, coastal stationary netting has a clear negative effect on lamniform sharks, particularly during spring and summer. The off season for Turkish marine fisheries lasts from 1st May to 1st September; however, small-scale fishermen are allowed to continue fishing during the off season. Therefore, *C. carcharias* can be highly vulnerable to coastal fisheries.

Regarding the Marmaric and Aegean records of *C. carcharias* (FERGUSSON, 1996; KABASAKAL, 2003; KABASAKAL & KABASAKAL, 2004; KABASAKAL, 2008), a total of 33 great white sharks, including the specimens of the present study, were reported from the mentioned area to date. Besides the clear numerical dominance of great white shark recordings from the western and central Mediterranean (FERGUSSON, 1996), the incidental capture of neonates in Edremit Bay (northeastern Aegean Sea) indicates a new perspective on the occurence of *C. carcharias* in the Mediterranean. Therefore, it's necessary to carry-out regular monitoring in Edremit Bay in order to clarify the actual status of the breeding possibility of great white sharks in that area.

Due to the vulnerable status of white sharks in the Mediterranean Sea, it is included in Appendix 2 of the Berne Convention and Appendix 2 of the Barcelona Convention. Hence, it is considered as vulnerable by IUCN and FAO, and proposed for CITES listing on Appendix I and II (SERENA, 2005). Contrary to international efforts for protecting *C. carcharias*, there have been no attempts to set regulations for the conservation of the species in Turkish waters. In ecological terms, the white shark is a "K-Selected*"* species with slow growth, late maturation and low fecundity which means that once the population of white shark is overfished, it would take many years for recovery. All of these facts necessitate the carrying out of extensive research to determine the current status of the white shark in Turkish waters, as well as monitoring of the interactions between the species and fishing activities.

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Nalazi dva netom okoćena psa ljudoždera, *Carcharodon carcharias* (Linnaeus, 1758) (Lamniformes; Lamnidae) u turskim vodama sjevernog Egejskog mora

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SAŽETAK

Novookoćena jedinka psa ljudoždera uhvaćena je 1. srpnja 2008. pomoću mreže stajaćice u blizini grada Altınoluka (Edremit zaljev, sjeverno Egejsko more), a nakon tri dana slijedio je ulov novog juvenilnog primjerka na istoj lokaciji pomoću pridnenog parangala. Prethodno ovim nalazima, ukupna duljina (TL) najmanjeg živućeg primjerka psa ljudoždera u Mediteranu je iznosila 142 cm TL i to juvenilne ženke, uhvaćene u blizini talijanskog gradića Mazara del Vallo, 11. kolovoza 1983. (kataloški broj: MSI-0285J, appendix 1, FERGUSSON, 1996). Stoga je moguće da je jedinka br. 1 (125,5 cm TL) u ovoj studiji najmanji primjerak tek okoćenog psa ljudoždera u Mediteranu.

Ključne riječi: *Carcharodon carcharias*, pas ljudožder, reprodukcija, mrijestilište, novi okot, morfometrija, sjeverno Egejsko more